PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B60R 21/28	A1	(11) International Publication Number: WO 96/40541 (43) International Publication Date: 19 December 1996 (19.12.96)

(21) International Application Number: PCT/US96/08779

(22) International Filing Date: 5 June 1996 (05.06.96)

(30) Priority Data:
08/487,030 7 June 1995 (07.06.95) US

(71) Applicant *(for all designated States except US)*: TAKATA MOSES LAKE, INC. [US/US]; 9255 Randolph Road N.E., Moses Lake, WA 98837 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: WOOD, James, Charles [US/US]; 1629 Fairway Drive, Moses Lake, WA 98837 (US). KUMKOSKI, James, Marvin [US/US]; 6079 Cottonwood Court, Clarkston, MI 48346 (US).

(74) Agent: HUGHES, Richard, L.; Bogle & Gates, P.L.L.C., Two Union Square, 601 Union Street, Seattle, WA 98101-2346 (US).

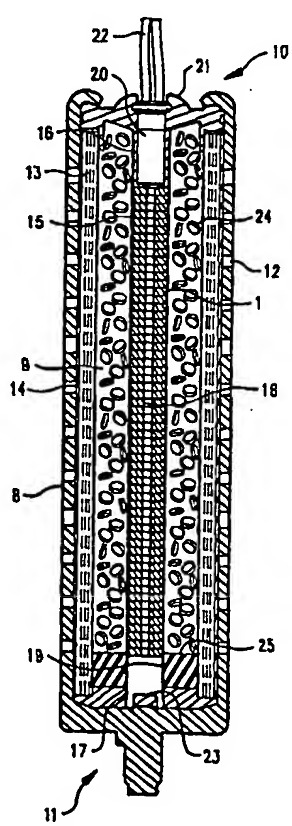
(81) Designated States: DE, JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: AIRBAG INFLATOR SYSTEM

(57) Abstract

A vehicle airbag inflator (10) utilizing gas-generating propellant elements (1) containing a central aperture (18). The propellant elements are aligned adjacent to each other in a column so that their central apertures form an axially symmetrical ignition channel (18) extending through the propellant column. The size of the ignition channel formed by the central apertures of the propellant elements is such that an initiating explosion resulting from the activation of an associated initiator propagates substantially instantaneously along the ignition channel, igniting the propellant. A preferred ignition channel diameter is from about 1-5 millimeters. Applicant's novel inflation system eliminates the need for a propellant ignition cord or other ignition enhancer, while simultaneously enhancing the time to first pressure parameter for the system, reducing manufacturing costs and reducing the size of the system.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

AIRBAG INFLATOR SYSTEM

This invention relates generally to a vehicle airbag collision protection system, and more particularly, to a novel inflator and gas-generating propellant useful in such systems. The invention also includes a method for igniting gas-generating propellant charges.

BACKGROUND INFORMATION

Air bag collision protection systems for motor vehicles generally utilize folded bags mounted on the steering wheel, dashboard or doors of the vehicle, which bags are rapidly inflated when the vehicle is involved in a collision, thereby protecting the driver and/or passenger(s). The airbag is inflated by a gas generator, or inflator, which in turn is activated by a signal from a collision sensor.

The inflator contains one or more gas generating materials, or propellants, typically in solid form. When ignited, the propellant generates gas, which inflates the airbag. Although the propellant is combustible, to initiate and accelerate ignition of the propellant, most inflators utilize ignition enhancing materials associated with the propellant, including, e.g., a pyrotechnic "ignition cord". The ignition enhancing material is in turn typically ignited by an "initiator", usually containing an explosive pyrotechnic material, which is activated by an electrical signal from the collision sensor.

The airbag must inflate rapidly enough, and to a sufficient extent, under a wide range of conditions, including, e.g., different temperature extremes, in order to protect the occupant from the effects of a collision. The optimum rate of airbag inflation can vary depending on the type of vehicle and its collision profile, and whether the airbag is designed for the driver or the passenger, or whether it is designed for a side-impact collision. For example, it is advantageous for a passenger side airbag to have a "soft-onset" inflation, i.e., to have gradual initial pressure rise, or inflation, followed by a more rapid inflation, in order to minimize risk of injury from an airbag expanding too rapidly into an out of position passenger, in particular, a child.

Various approaches have been used in the prior art to achieve controlled, rapid ignition of gas-generating propellants in airbag inflators.

Cunningham U.S. patent 4,950,458 utilizes a "rapid detonating cord", or ignition cord, further enhanced by an associated booster charge to achieve rapid ignition of propellant material.

Garner, et al., U.S. patent 4,246,051 relates to an ignition enhancer coating for propellants.

Chan, et al., U.S. patent 5,351,619 relates to a pyrotechnic ignitor film layered over a propellant, or alternatively, inserted into the central apertures of propellant disks so configured.

Pietz U.S. patent 4,758,287 relates to a porous propellant disk with a central cylindrical core designed to encase an igniting enhancer and a process for preparing the propellant disk.

Bender U.S. patent 5,101,730 relates to propellant disks containing a central aperture, arranged in a column within a combustion chamber so that an ignition channel is defined by the apertures. Bender requires outlet channels on the top and underside of the disks extending radially from the central aperture to the disk rim.

All of these approaches to solving the problem of obtaining uniform, rapid combustion of propellant disks utilize ignition enhancing materials, in addition to an explosive initiator, to accelerate the combustion of the propellant.

The development of the field of airbag safety restraint systems has been driven, in part, by the need to increase the reliability and reduce the cost of the systems, so they could become standard, affordable safety items in a wide range of motor vehicles. The gas generator or inflator is typically the largest component of an airbag collision protection system. Therefore, an important factor influencing the cost and vehicle design compatibility of an airbag system is the inflator size. A smaller inflator also minimizes the vehicle design modifications needed to utilize the airbag system.

Thus, there is a need and a demand for an improved airbag inflating system that will provide desireable inflation characteristics and will be of maximum compactness. There is also a need and demand for an improved airbag inflating system with inflation parameters that can be easily manipulated depending on the proposed location of the airbag and the type of vehicle it will be installed in, without requiring extensive production modifications.

SUMMARY OF THE INVENTION

According to an embodiment of the present invention, there is provided an inflator for emitting gas into a vehicle airbag, utilizing propellant disks containing a central aperture. The propellant disks are aligned adjacent to each other in a column within a combustion chamber so that the central apertures of the disks form a central, axially symmetrical ignition channel extending through the propellant column. The diameter of the ignition channel is such that activation of an associated initiator propagates an initiating explosion substantially instantaneously along the ignition channel, resulting in a concomitant, substantially instantaneous ignition of the propellant disks. A preferred ignition channel diameter is about 1-5 millimeters.

This propellant design and its configuration in the inflator eliminates the need for an ignition cord or similar ignition enhancer to ignite the propellant (although one can be used, if desired), and permits a smaller inflator which is cheaper and safer to manufacture, while at the same time, maintaining or reducing the time to first pressure performance characteristics of the inflator and enhancing the ability to custom tailor inflation parameters depending on the type of vehicle or the location of the airbag.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention and its advantages, an embodiment of the invention is described in the accompanying drawings and detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view, in cross section, illustrating the geometry of one embodiment of applicants' novel propellant.

FIG. 2 is a top view of the disk shown in FIG. 1.

FIG. 3 is a side view, in cross section, illustrating one embodiment of an inflator assembly employing applicants' propellant disks.

FIG. 4 is a side view, in cross section, illustrating applicants' current commercial inflator assembly utilizing a standard ignition propellant cord.

FIG. 5-7 are "Tank" curves comparing the performance of the embodiment of applicants' novel inflator depicted in FIG. 3 to applicants' commercial inflator depicted in FIG. 4, at temperatures of -40°C, 23°C and 80°C, respectively.

FIG. 8 is a top view of an automobile with applicants' novel inflator assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT AND BEST MODE OF THE INVENTION

FIGS. 1-2 show one embodiment of applicants' novel propellant. This embodiment shows applicants' propellant in the form of a disk. The shape of the propellant can be otherwise configured if desired. The diameter of the central aperture **2** of applicants' disk **1** can vary depending on the desired combustion speed and propellant composition and is sufficiently narrow to cause substantially instantaneous propagation of an initiating explosion along the ignition channel formed by the apertures when the disks are stacked in a column in a combustion chamber. "Substantially instantaneously" is used here to mean rapidly enough to ignite the propellant disks so that an airbag inflation rate is achieved which is suitable to help protect the vehicle occupants from the effects of a collision.

The preferred central aperture diameter is about 1-5 millimeters in diameter, and most preferably, about 3.18 millimeters. The outside diameter **3** of the disk will also vary depending on desired combustion speed, but preferably is about 7-15 millimeters. As illustrated in FIG. 1, in its preferred embodiment the propellant disk has a "stepped" configuration, so that the central portion **4** of the disk is thinner than its outer portion **5**, creating air spaces within the propellant column. The height, or thickness **6**, of the outer portion of the disk may vary depending on, e.g., desired combustion speed, but preferably is about 1-10 millimeters. The design of applicants' propellant disks, and their configuration within applicants' inflator eliminates the need for radially extending outlet channels in the disks, although those could be included if desired.

Applicants' novel propellant can be composed of a variety of gas-generating compositions having the desired burning rate, non-toxicity and flame temperature. A preferred gas generating composition contains about eighty-five weight percent sodium azide and about fifteen weight percent potassium perchlorate. The propellant

disks are manufactured conventionally, such as, pressmolding in dies corresponding to the desired configuration of the disks.

FIG. 3 shows an inflator assembly 7 according to the invention. The inflator assembly includes a generally cylindrical casing or housing 8, enclosing a combustion chamber 9. The combustion chamber 9 has a first end 10 and a second end 11 closed in a sealing manner. A plurality of apertures or ports 12 are formed on the housing 8 for discharging gas from the inflator. A generally cylindrical screen 13 is positioned adjacent to the inner wall of the housing 8, which screen filters and cools the gas generated by the inflator.

A layer of rupturable aluminum foil 14, or other suitable material is provided between the housing 8 and the screen 13, which foil hermetically seals the inflator against moisture and other potentially deleterious constituents of the environment to which it is exposed. The foil 14 is designed to rupture when the internal pressure of the inflator increases due to the combustion of the propellant disks contained therein.

A generally cylindrical ignition tube 15, with a first end 16 and a second end 17, is centrally positioned within the annular space of the combustion chamber 9, aligned axially to the housing 8. Stacked within the ignition tube 15, are a plurality of applicants' novel propellant disks 1. The propellant disks 1 are arranged adjacent to each other in a column, such that the central apertures of the disks form a relatively linear ignition channel 18. A retainer 19 is located at the second end of the ignition tube 15 to hold the propellant disks 1 in place in the ignition tube. The ignition tube 15 contains a plurality of ports or apertures (not shown), for discharging gas from the propellant contained therein.

An electroexplosive ignition device, or initiator assembly 20, such as that manufactured by OEA, Inc., P.O. Box 10488, Denver, Colorado 80210, is mounted at the first end of the combustion chamber, centrally thereof, and is held in place by closure 21. The initiator 20 includes a conventional electric squib internally connected with a resistance wire and associated explosive ignition material, and is electrically connected by wires 22 to a collision sensor (not shown). The initiator 20 is arranged at the first end 16 of the ignition tube 15, and in operative relationship with the propellant disks 1, contained therein.

An auto ignitor 23 is disposed centrally at the second end of the combustion chamber, under the retainer 19. In the event of a fire, either during storage or shipping, or when installed in the vehicle, the auto ignitor 23 is designed to ignite and burn the gas generating materials and any additional pyrotechnic material in the inflator at a temperature which is lower than the natural ignition temperatures of these materials, to prevent an explosion. A preferred autoignition compound is comprised of about fifty-eight weight percent potassium perchlorate, about twenty-one weight percent 5-aminotetrazol and about twenty-one weight percent 2,4-dinitrophenyl-hydrazine.

Also contained within the combustion chamber 9 of the inflator, and placed around the ignition tube 15, are a plurality of secondary propellant pellets 24. In the embodiment shown, the secondary propellant pellets 24 are "randomly packed" inside the combustion chamber 9, as opposed to being axially aligned and stacked in a column, as with applicants' novel propellant disks 1 contained within the ignition tube 15. The secondary propellant pellets 24 are held in place within the combustion chamber by spacer element 25. The secondary propellant pellets 24 can be composed of a variety of gas generating compounds. In one embodiment of applicants' invention, the composition of the secondary propellant 24 is selected to burn more slowly than applicants' novel propellant disks 1. The secondary propellant 24 is preferably comprised of about sixty-two weight percent sodium azide, about thirty-six weight percent iron oxide and about two weight percent potassium nitrate. The secondary propellant can also manufactured conventionally, usually by pressmolding.

Functioning of the inflator 7 begins with an electrical signal from the collision sensor to the initiator 20. This signal causes the explosive material in the initiator 20 to detonate. The detonation propagates substantially instantaneously along the ignition channel 18 formed by the internal apertures of the central propellant disks 1, igniting the propellant disks. Without being bound by any theory, it is believed that the narrow diameter of the ignition channel 18, preferably about 1-5 millimeters, channels the initiating explosion into a supersonic shockwave that allows for substantially instantaneous propagation of heat and energy along the length of the central propellant disks 1 from the point of initial ignition, eliminating the need to

utilize an ignition cord or other additional ignition enhancing material to achieve that result.

As the hot gas generated by the ignition of the central propellant disks **1** passes through the ports of the ignition tube **15**, it ignites the secondary propellant **24**. The gas passes through the filter screen **13**, and when the pressure within the combustion chamber **9** reaches a threshold value, the foil **14** ruptures, discharging gas into, and beginning the inflation of the airbag.

FIG. 4 shows the previous commercial embodiment of an inflator **26** utilized by applicants in their airbag collision protection systems. This inflator comprises a combustion chamber **27** with a perforated central ignition tube **28** filled with propellant **29**, with secondary propellant **30** packed around the ignition tube. The preferred chemical compositions of the two propellants are the same as those utilized in applicants' novel gas generator. However, as illustrated in FIG. 4, the central propellant **29** is not axially aligned but is instead randomly packed around an ignition cord **31**, in operative relation with an initiator **32**.

The functioning of the inflator **26** depicted in FIG. 4 also begins with an electrical signal from a collision sensor to the initiator **32**. The signal causes the explosive ignition material in the initiator **32** to detonate. However, the propellant **29** in the ignition tube **28** is not configured to form an ignition channel to propagate the igniting detonation. Instead, the initiator **32** ignites the ignition cord **31** which in turn ignites the central propellant **29**. The hot gas generated by the ignition of the central propellant **29** ignites the secondary propellant **30**.

FIGS. 5-7 graphically illustrate a comparison of the performance at three different temperature extremes, of the FIG. 4 inflator (depicted as a solid line), and the gas inflator according to the embodiment of the invention depicted in FIG. 3 utilizing applicants' novel propellant disks (depicted as a dashed line). The curves show the pressure rise in KiloPascals in a 60 liter test tank when the inflator is activated, plotted against time in milliseconds. "Time to first pressure" is the elapsed time between initiation or activation of the inflator, and the first registration of pressure in the tank, and is illustrated in FIGS. 5-7 as the beginning of the curve. Time to first pressure is an important indicator of the performance characteristics of an airbag inflator.

Generally, the shorter the time to-first pressure, the more reliable the inflator system will be in timely inflating the airbag after a collision, especially at low temperatures.

As illustrated in FIGS. 5-7, even though applicants' novel gas generator does not utilize an ignition cord or other ignition enhancer to ignite the central propellant, its time to first pressure is significantly shorter than that of the standard inflator shown in FIG. 4, even during cold ignition. As illustrated in FIG. 5, at a temperature of -40°C, applicants' novel inflator achieves a time to first pressure of about 4 milliseconds, as compared to about 8 milliseconds for the FIG. 4 inflator using an ignition cord. Comparable time to first pressure enhancement at ambient and elevated temperatures is shown in FIGS. 6 and 7.

FIG. 8 shows an automobile **33** containing applicants' novel inflator 7.

Removing the need for an ignition enhancer, such as an ignition cord, from an inflator, results in a substantial cost saving per unit. The configuration of applicants' propellant disks in the ignitor tube also results in a more efficient reaction allowing a reduction in the amount of the propellant contained therein, while still maintaining the same overall gas output. Thus, applicants' invention provides an inflator which can provide desired inflation characteristics with minimal ignition material per volume of gas generant. Applicants' inflator also exhibits enhanced time to first pressure per volume of ignition material.

Additionally, because of high packing density achieved by stacking the central propellant as opposed to random packing, the embodiment of applicants' novel inflator shown in FIG. 3 is 210 mm in length, compared to 254 mm for the FIG. 4 standard inflator, a more than 13% reduction in length. Furthermore, applicants' design eliminates the need for outlet channels on the propellant disks to achieve adequate gas conductance into the airbag, further decreasing production costs.

Still another advantage of applicants' inflator system follows from the improved ability to vary the onset and rate of inflation. This ability is important to allow for tailoring an airbag collision protection system depending on whether the system will be utilized to protect the driver, a passenger, or for protection from a side impact. The preferred onset and rate of inflation can also vary depending on the particular collision profile or "crash pulse" of the vehicle. The onset and inflation rate of a particular inflator is graphically illustrated by the shape of the "tank" curves

shown in FIGS. 5-7. Varying the amount of gas produced in the early part of the propellant burn to that produced in the later part of the burn will change the curve shape and vary the inflator's onset and inflation rate.

Applicants' novel inflator allows a manufacturer to easily modify the curve shape to fit a particular inflation requirement without the need to vary the amount of an ignition enhancer or to vary the propellant composition, and without substantially reconfiguring the inflator design. Applicants' preferred embodiment, as described in FIG. 3, allows extensive flexibility in curve shaping simply by varying the ratio of the fast burning central propellant to the slower burning main propellant. Extensive curve shaping can also be achieved by "ballistic tailoring", i.e., by varying reaction velocity of the propellants utilized in applicants' inflator by changing the thickness or diameter of the propellant disks and/or by varying the diameter of the propellant ignition channel, to vary the burn surface area. The inflation parameters of an embodiment of applicants' gas generator which utilizes only the central propellant (not shown) can also be changed by manipulating the thickness of the central propellant disks and the diameter of the ignition channel.

It is not intended that the scope of this invention be limited to the specific embodiments that have been described and illustrated. Rather, the scope of the invention is determined by the scope of the appended claims.

WHAT IS CLAIMED IS:

1. An inflator comprising:

a first plurality of gas generating propellant elements having an aperture, said propellant elements arranged adjacent to each other in a column so that the apertures are substantially aligned to form an ignition channel, the apertures having a size sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the ignition channel.

2. The inflator according to claim 1, wherein the aperture is located substantially centrally on the propellant element.

3. The inflator according to claim 1, further comprising an initiator for applying an initiating explosion, in ignition transmission relationship with the ignition channel.

4. The inflator according to claim 1, wherein the size of the aperture is about 1-5 millimeters.

5. The inflator according to claim 1, wherein the propellant elements are in the shape of a disk.

6. The inflator according to claim 1, wherein the central portion of the propellant elements are thinner than the outer portion of the propellant element.

7. The inflator according to claim 1, wherein the propellant elements are composed of about eighty-five weight percent of sodium azide and fifteen weight percent of potassium perchlorate.

8. The inflator according to claim 1, further comprising a second plurality of gas generating propellant elements provided in ignition transmission relationship to the first plurality of gas generating propellant elements.

9. The inflator according to claim 8, wherein the second propellant elements are composed of a gas generating composition which has a slower combustion rate than the composition of the first propellant elements.

10. The inflator according to claim 9, wherein the second propellant elements are composed of about sixty-two weight percent sodium azide, about thirty-six weight percent iron oxide, and about two weight percent potassium nitrate.

11. An inflator comprising:

an elongated housing forming a combustion chamber having a central axis, with a plurality of outlet ports formed on the housing,

an elongated ignition tube centrally located within the combustion chamber in coaxial relation thereto, having a plurality of outlet ports formed on the ignition tube,

a first plurality of gas generating propellant elements having an aperture, the first propellant elements arranged adjacent to each other in a column within the ignition tube so that the apertures are substantially aligned to form an ignition channel coaxially related to the ignition tube, the apertures of the first propellant elements having a diameter sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the ignition channel, igniting the first propellant elements, and

a second plurality of gas generating propellant elements provided in the combustion chamber in ignition transmission relationship to the first propellant elements.

12. The inflator according to claim 11, wherein the aperture is located substantially centrally on the first propellant element.

13. The inflator according to claim 11, further comprising an initiator for applying an initiating explosion, in ignition transmission relationship with the first propellant elements.

14. The inflator according to claim 11, wherein the size of the aperture of the first propellant elements is about 1-5 millimeters.

15. The inflator according to claim 11, wherein the first propellant elements are composed of a gas generating composition which has a slower combustion rate than the gas generating composition of the second propellant elements.

16. The inflator according to claim 11, wherein the first propellant elements are composed of about eight-five weight percent of sodium azide and fifteen weight percent of potassium perchlorate, and the second propellant elements are composed of about sixty-two weight percent sodium azide, about thirty-six weight percent of iron oxide and about two weight percent of potassium nitrate.

17. The inflator according to claim 11, wherein the central portion of the first propellant elements are thinner than the outer portion of the first propellant elements.

18. A method for igniting a particulate gas generating charge, comprising the steps of providing gas-generating propellant elements having an aperture, and arranging those elements substantially adjacent to each other in a column so that the apertures are substantially aligned to form an ignition channel, the apertures having a size sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the ignition channel.

19. The method according to claim 18 wherein an initiating explosion is applied to the ignition channel.

20. A gas generating element for use in an airbag inflator, said element having an aperture of such size that when the element is arranged in a column within the inflator, an ignition channel is formed of sufficiently narrow size to allow an

initiating explosion applied thereto to propagate substantially instantaneously along the ignition channel.

21. The gas generating element according to claim 20, wherein the aperture is located substantially centrally on the propellant element.

22. The gas generating element according to claim 20, wherein the size of the aperture is about 1-5 millimeters.

23. The gas generating element according to claim 20, wherein the element is in the shape of a disk.

24. The gas generating element according to claim 20 wherein the central portion of the gas generating element is thinner than the outer portion of the gas generating element.

25. The gas generating element according to claim 20, wherein the gas-generating material is a composition of about eighty-five weight percent sodium azide and about fifteen weight percent potassium perchlorate.

26. A vehicle airbag collision protection system, comprising an inflator with a first plurality of gas generating propellant elements having an aperture, said propellant elements arranged adjacent to each other in a column so that the apertures are substantially aligned to form an ignition channel, the apertures having a size sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the ignition channel, and an airbag which is inflated by the gas generated by the inflator.

27. The collision protection system according to claim 26, wherein the aperture is located substantially centrally on the propellant element.

28. The collision protection system according to claim 26 wherein the inflator further comprises a second plurality of gas generating propellant elements provided in ignition transmission relationship to the first plurality of propellant elements.

29. The collision protection system according to claim 28 wherein the second plurality of propellant elements are composed of a gas generating composition which has a slower combustion rate than the gas generating composition of the first plurality of propellant elements.

30. The collision protection system according to claim 29, wherein the first propellant elements are composed of about eight-five weight percent of sodium azide and fifteen weight percent of potassium perchlorate, and the second propellant elements are composed of about sixty-two weight percent sodium azide, about thirty-six weight percent of iron oxide and about two weight percent of potassium nitrate.

31. A vehicle containing an airbag collision protection system, comprising an inflator with a plurality of gas generating propellant elements having an aperture, said propellant elements arranged adjacent to each other in a column so that the apertures are substantially aligned to form an ignition channel, the apertures having a size sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the ignition channel, and an airbag which is inflated by the gas generated by the inflator, responsive to an impact directed to the vehicle.

32. The vehicle according to claim 31, wherein the aperture is located substantially centrally on the propellant element.

33. The vehicle according to claim 31 wherein the inflator further comprises a second plurality of gas generating propellant elements provided in ignition transmission relationship to the first plurality of propellant elements.

34. The vehicle according to claim 33 wherein the second plurality of propellant elements are composed of a gas generating composition which has a slower combustion rate than the gas generating composition of the first plurality of propellant elements.

35. The vehicle according to claim 34, wherein the first propellant elements are composed of about eight-five weight percent of sodium azide and fifteen weight percent of potassium perchlorate, and the second propellant elements are composed of about sixty-two weight percent sodium azide, about thirty-six weight percent of iron oxide and about two weight percent of potassium nitrate.

36. An inflator comprising a gas generating propellant element having an aperture of a size sufficiently narrow to propagate an initiating explosion applied thereto substantially instantaneously along the aperture.

FIG. 1

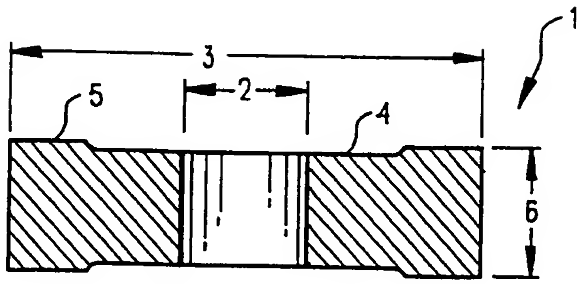


FIG. 2

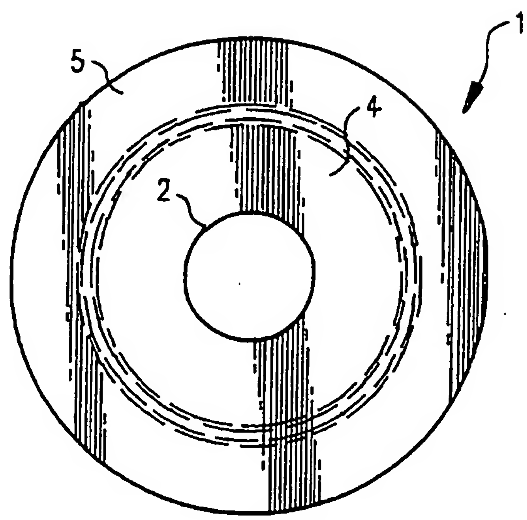


FIG. 8

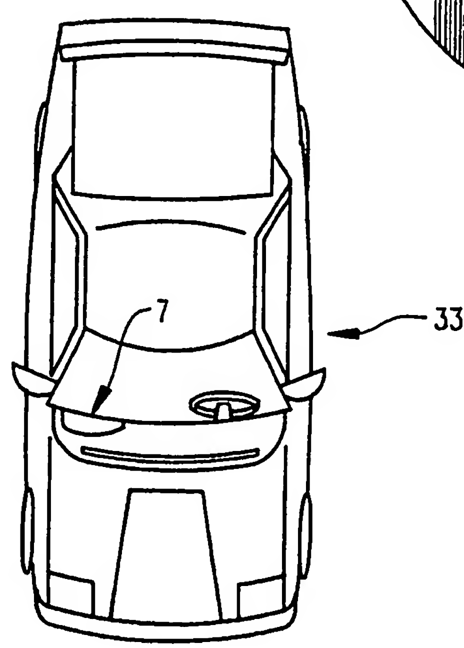


FIG. 3

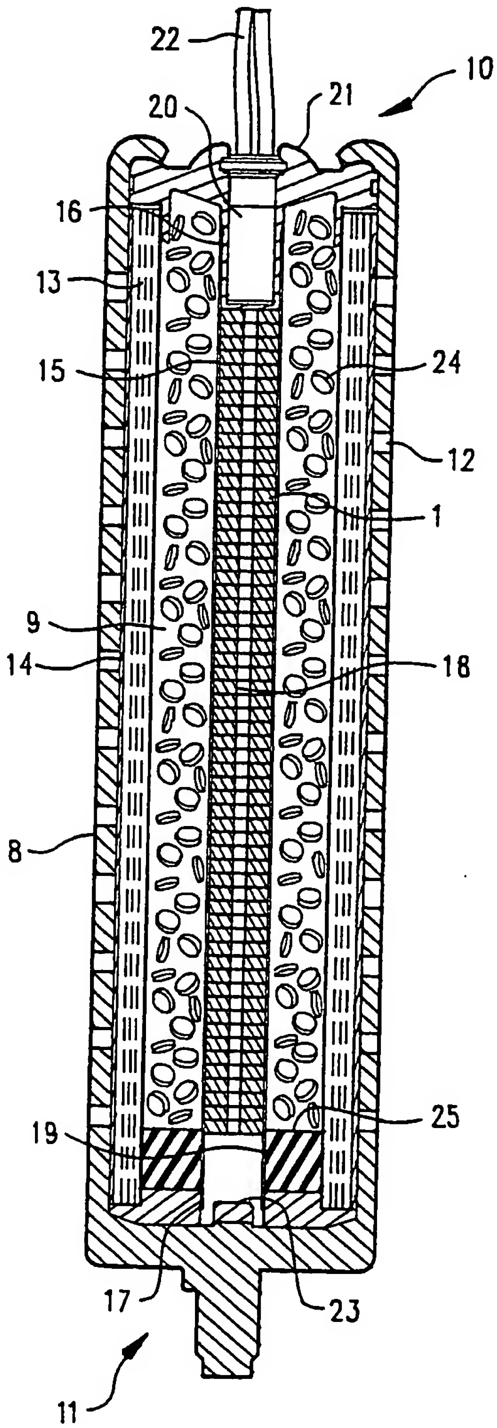


FIG. 4

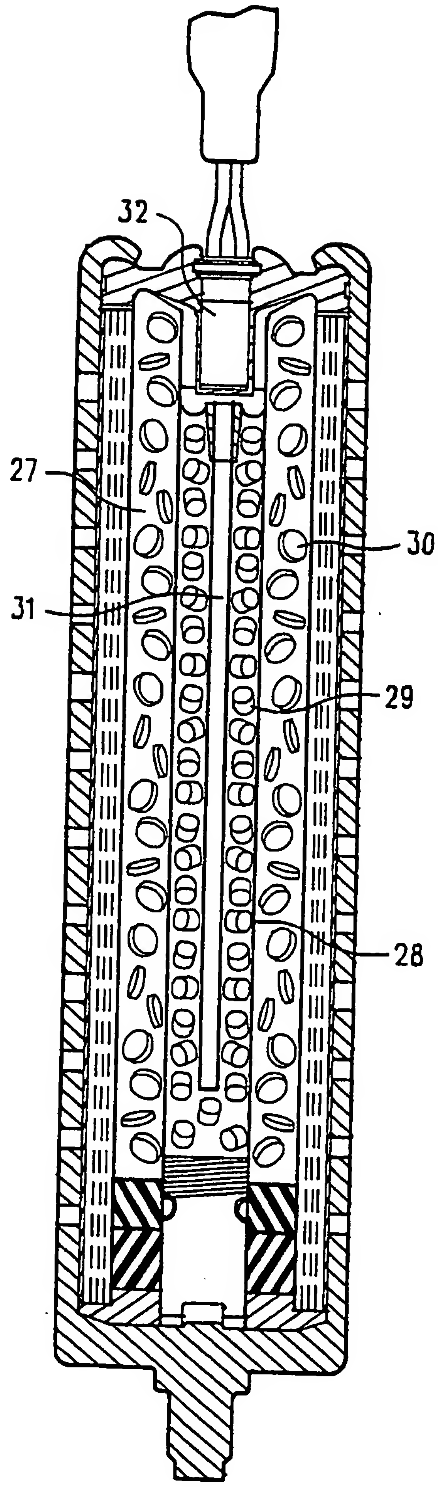


FIG. 5

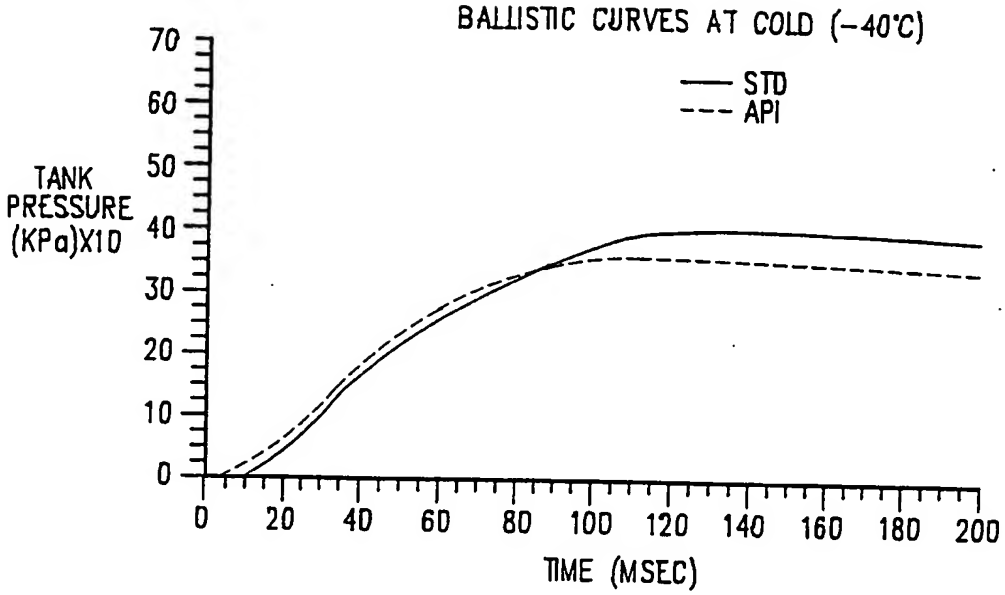

BALLISTIC CURVES AT COLD (-40°C)
STD
API
TANK PRESSURE (KPa)X10
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
TIME (MSEC)

FIG. 6

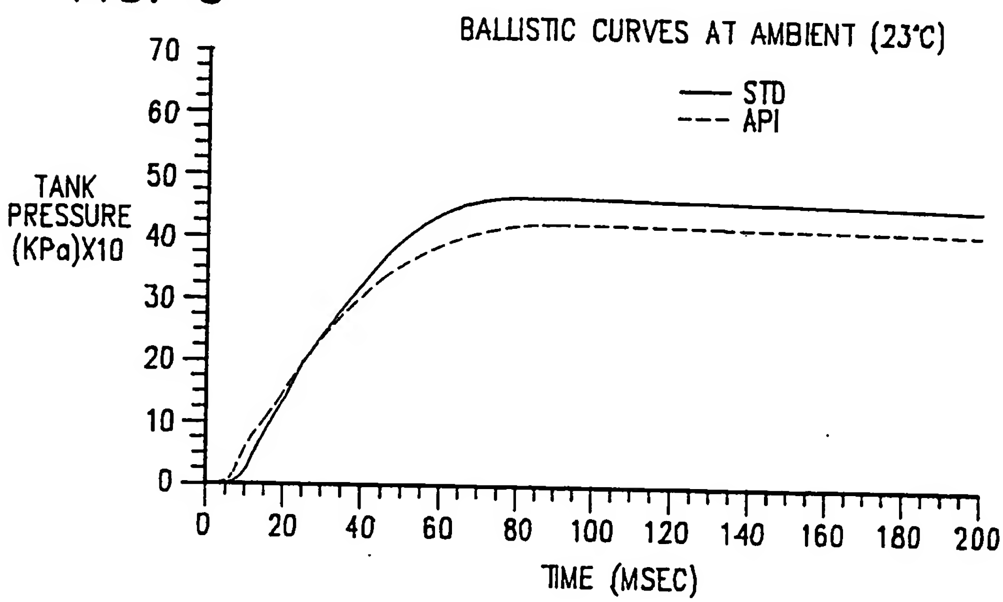
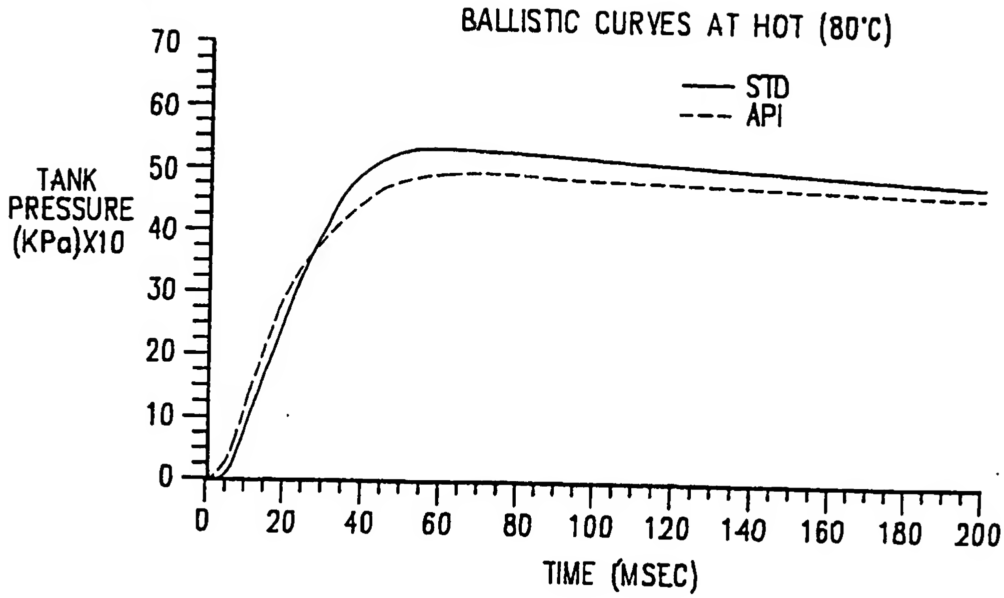

BALLISTIC CURVES AT AMBIENT (23°C)
STD
API
TANK PRESSURE (KPa)X10
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
TIME (MSEC)

FIG. 7


BALLISTIC CURVES AT HOT (80°C)
STD
API
TANK PRESSURE (KPa)X10
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
TIME (MSEC)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/08779

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B60R 21/28
US CL :280/741
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 280/736, 741; 102/530, 531

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US, A, 4,806,180 (Goetz) 21 February 1989, see entire document.	1-3, 5, 18-19, 26-27, 31-32, 36 -------------- 4, 6-7
X ---- Y	US, A, 5,101,730 (Bender et al.) 7 April 1992, see entire document.	18-24 ---------- 1, 4, 6, 8-10, 11-17, 25-26, 28-31, 33-35
Y	US, A, 4,758,287 (Pietz) 19 July 1988, see col. 2, lines 49-55 and col. 8, lines 11-19.	7, 10, 16, 25, 30, 35

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 JULY 1996	17 JUL 1996

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	PAUL N. DICKSON
Facsimile No. (703) 305-3230	Telephone No. (703) 308-2089

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,878,690 (Cunningham) 7 November 1989, see entire document.	1, 8-10, 11-17, 26, 28-31, 33-35